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A Deep Voice From Deep Space

Black Hole's Profoundly Low Note May Leak a Secret of Star Formation

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Astronomers for the first time have detected sound waves emanating from a supermassive black hole, researchers said yesterday. With a frequency of 10 million years, the wave is the deepest "note" ever found in the universe -- a B-flat that is 57 octaves below a piano's middle C.

Researchers said heat generated by the sound wave may explain why gases moving within clusters of galaxies do not cool down to form more stars -- an anomaly that has puzzled astrophysicists for years.

"We see about three ripples; then they die out," said lead researcher Andrew Fabian, an astrophysicist at the Institute of Astronomy in Cambridge, England. "It could be distance, or the limitations of the telescope, but we think they are putting energy into the gas to stop it from cooling any further."

Fabian and co-investigator Steven Allen, also of the Institute of Astronomy, used NASA's Chandra X-ray Observatory orbiting Earth to detect and photograph the sound waves coming out of a supermassive black hole at the center of the Perseus cluster, a group of galaxies about 250 million light years from Earth.

And although the Perseus sound waves are the first ever detected, scientists said there was no reason why other black holes could not propagate sound waves of their own. In fact, said Kim Weaver, an astrophysicist at Goddard Space Flight Center, "I'm sure astronomers are going to look at more clusters" to search for the same phenomenon.

Black holes, once the stuff of astrophysical theory, are collapsed stars whose cores are points of infinite density, truly "black" since neither light nor matter can escape them. "Supermassive" black holes, like those at the center of clusters, are less widely understood, but may result from the collapse of a supermassive star or a cluster of neutron stars or a cluster of star-sized black holes.

"It's an object between 1 million and 1 billion solar masses in round numbers," said University of Michigan astronomer Douglas Richstone. "It fits inside the radius of the Earth's orbit."

Matter, mostly gas, disappears forever into the vortex of a black hole when it crosses a boundary of no return called the "event horizon." But in the Perseus cluster and at other black holes, astronomers have observed two jets of gas spraying out from the edge of the holes to form a figure-eight-shaped pair of cavities on either side. Fabian likened this phenomenon to a child blowing bubbles through a straw in a glass of milk.

"It's not really clear how it works, but for one of several reasons, there are tremendous outward forces on the gas trying to go in," Richstone said. "This gas gets picked up and squirted out. It may be a very small fraction of the mass, but it is accelerated to tremendous speeds." It also reaches temperatures of tens of millions of degrees, Fabian said, so hot that the gas begins to emit X-rays that can be detected and photographed by the

space-based Chandra. What the X-ray photographs reveal are ripples radiating from the cavities through the surrounding gas, generated by the pressure of the two jets -- again, like a child blowing air across the surface of a glass of milk.

"The concentric ripples produce one cycle every 10 million years," Fabian said. "This tells us what the note is" -- a B-flat pitched far below the ability of the human ear to hear it. "We think it's the deepest note that's ever been detected," Fabian added. "It turns out that the loudness of the sound is comparable to that of human speech, but the [wavelength] of the ripples is 30,000 light years -- bigger than a galaxy."

Chandra's photographs show three ripples moving outward from the black hole, after which they appear to dissipate, Fabian said. There could be several reasons for this, he added. The telescope may not be able to embrace a wider piece of the heavens and keep the ripples in focus, or the ripples may simply die out for lack of matter -- sound cannot travel in a vacuum.

But Fabian and Allen suggested that the waves may disappear because the gas through which they travel is absorbing energy. This, Fabian and Allen said, could explain why gases near the center of clusters do not form more stars.

"The gas should be cooling down over time, and the gas in the center should be cooling the fastest," Goddard's Weaver said. "This discovery may give us a clue about what is happening to cause the gas not to cool. It's keeping the stars from forming."

Bruce Margon, associate director for science at Baltimore's Space Telescope Science Institute, agreed that the Chandra discovery "appears to be an elegant solution" to this dilemma, but "whether everybody in the astronomical community will accept it is another thing. Also, so far we've only seen it in one galaxy."